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STAT

12-INCH LABORATORY  
ELECTROMAGNET

Magnet

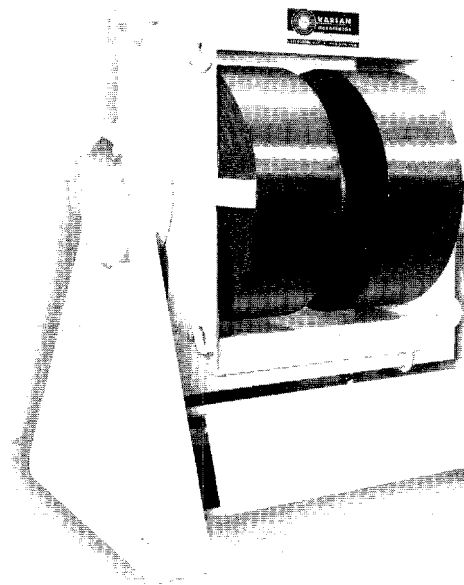
V-4012

## DATA SHEET

Large magnitudes and volumes of uniform magnetic field for highest precision research applications are provided by the Varian Model V-4012 Twelve-Inch Laboratory Electromagnet. Removable cylindrical pole caps may be replaced by tapered conical pole caps for high field work. *For matching Regulated Magnet Power Supply and Voltage Regulator see V-2100 and V-2101 data sheet.*

## FEATURES

- TRUNNION-STYLE MOUNT permits choice of three yoke angles for best working access
- OPTICAL TECHNIQUES used to check flatness of cylindrical pole caps
- CAREFUL EXPLORATION made with *n-m-r*<sup>1</sup> apparatus to align caps for maximum field uniformity in specified air gap
- RIGID CONSTRUCTION insures maintenance of field uniformity after alignment process is completed
- ELECTROPLATED POLE CAP SURFACES minimize damaging effects of rust and wear
- INTERCHANGEABLE POLE CAPS; extra sets machined to provide desired air gap geometry available on order. Air gap may be varied by substitution of extra pole caps
- SEPARATELY AVAILABLE COIL SECTIONS permit wide latitude in matching magnet resistance to power supply
- COPPER-CLAD ENERGIZING COILS require no cooling water at lower currents; for continuous duty at higher currents, system may be operated with non-recirculating low-pressure tap-water cooling
- WATER FILTER supplied for cooling system



TEMPERATURE-SENSING THERMOCOUPLES buried in energizing coils for monitoring and protection of coils if cooling water is left off during continuous operation at higher energizing currents

ELECTRICAL AND WATER CONNECTIONS brought out to standard supplied connectors for direct attachment to power supply, water source, and drain

SURGE PROTECTION prevents damage to coils if sudden accidental magnet current interruption occurs

## GENERAL CHARACTERISTICS

## ELECTRICAL DATA

Number of energizing coils	2
Number of separately available winding sections per energizing coil	4
Number of turns per winding section	5,000
Total number of turns on magnet	40,000
Rated max. magnet current with water cooling	2.0 amp./winding section
Equilibrium power at rated max. magnet current with water cooling	4.7 kw

TYPICAL COLD START RESISTANCE DATA  
(Temp. at thermocouple position = 70° F.)

Resistance per winding section	130 ohms
Total resistance of series-connected <sup>2</sup> energizing coils	1040 ohms
Total resistance of parallel-connected energizing coils	16.3 ohms

TYPICAL EQUILIBRIUM RESISTANCE DATA  
(Temp. at thermocouple position = 125° F.)

Resistance per winding section	147 ohms
Total resistance of series-connected <sup>2</sup> energizing coils	1176 ohms
Total resistance of parallel-connected energizing coils	18.4 ohms

Max. allowable working voltage between energizing coils and grounded copper sheath encasing coils . . . 3750 volts

## COOLING DATA

Max. required water flow	2 gallons/min.
Pressure for max. flow <sup>4</sup>	15 lbs./in. <sup>2</sup>

## MECHANICAL DATA

Yoke angle with respect to vertical <sup>5</sup>	0°, 45°, or 90°
Approx. weight <sup>6</sup>	5600 lbs.

## NOTES . . .

- <sup>1</sup> nuclear magnetic resonance
- <sup>2</sup> Magnet is series-connected when used with V-2100 Power Supply.
- <sup>3</sup> Final equilibrium temp. at thermocouple position in coil interior for rated max. current of 2 amp./section and water cooling rate of 2 gpm. Approx. time required from cold start: 1.5 hours. Exterior surface temperature of coils rises only a few degrees, due to proximity of outermost layer of cooling coils.
- <sup>4</sup> Water system can withstand pressures up to 100 lbs./in.<sup>2</sup>.
- <sup>5</sup> Desired angle must be specified at time of order. If not specified, magnet will be delivered with yoke in vertical (0°) position.
- <sup>6</sup> For shipping weight, add 200 lbs. for crating.

Please address inquiries to: Special Products Division

Approved For Release 2005/04/22 : CIA-RDP83-00423R001500590022-7

# AIR GAP DATA

Pole diameter	11.9 inches
Air gap with pole caps removed <sup>7</sup>	5.25 inches
Diameter of standard cylindrical pole caps	11.9 inches
Max. permissible thickness of each member of standard pair of cylindrical pole caps <sup>8</sup>	2.25 inches
Min. permissible thickness of each member of standard pair of cylindrical pole caps <sup>9</sup>	1.0 inch
Air gap corresponding to pole caps of max. permissible thickness <sup>10</sup>	0.75 inch
Air gap corresponding to pole caps of min. permissible thickness <sup>10</sup>	3.25 inches

## NOTES . . .

- If the magnet is to be used for highest uniformity work (for example, one part in  $10^3$ - $10^4$  uniformity over  $10^{-3}$  cc.), pole caps should be removed and replaced only if high resolution n-m-r equipment is available for re-alignment.
- Max. thickness of cylindrical pole cap is set by necessity of attaching cap to pole by twelve peripheral counter-sunk screws. (A thirteenth threaded hole is provided on periphery for removal of cap in presence of small residual magnetism at zero energizing current). Pole caps of greater thickness are possible by use of axial bolt mounting mechanism available on special order.
- Min. thickness of cylindrical pole cap is set by difficulty in machining and lapping thin iron discs to degree of flatness required for highest homogeneity.
- Magnet may be ordered with cylindrical pole caps producing any specified air gap between 0.75" and 3.25". If not specified, magnet will be supplied with 1.75" gap.
- Search-coil data taken in median plane of air gap at current of 1.0 amp./section.
- On the gross scale tabulated, constant-field contours are circles with diameters twice the listed radial distance. For example, in a 1.75" air gap using standard 11.9" cylindrical pole caps, the circle of uniformity within which the field does not deviate from the central field by more than 1% has a diameter of 10".

## Typical Approximate Distributions of Magnetic Field in Air Gap Using Cylindrical Pole Caps of Various Thicknesses<sup>11</sup>

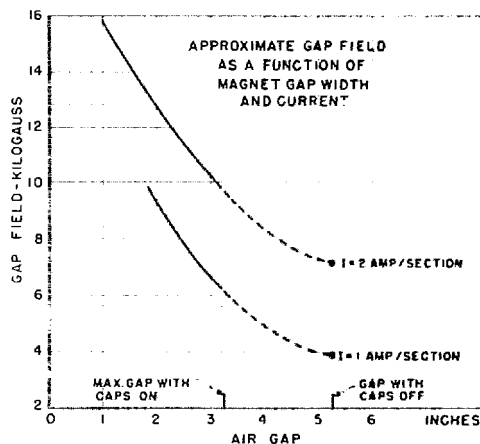
	Radial distance from center at which field has fallen off by 1% of central value <sup>12</sup>	Radial distance from center at which field has fallen off by 10% of central value <sup>12</sup>
5.25" air gap; (pole caps removed; 11.9" diam. pole surfaced exposed)	3 $\frac{1}{8}$ "	5"
3.0" air gap; 11.9" diam. pole caps . . .	4 $\frac{1}{4}$ "	5 $\frac{1}{2}$ "
1.75" air gap; 11.9" diam. pole caps . . .	5"	5 $\frac{5}{8}$ "

## Typical High Field Data

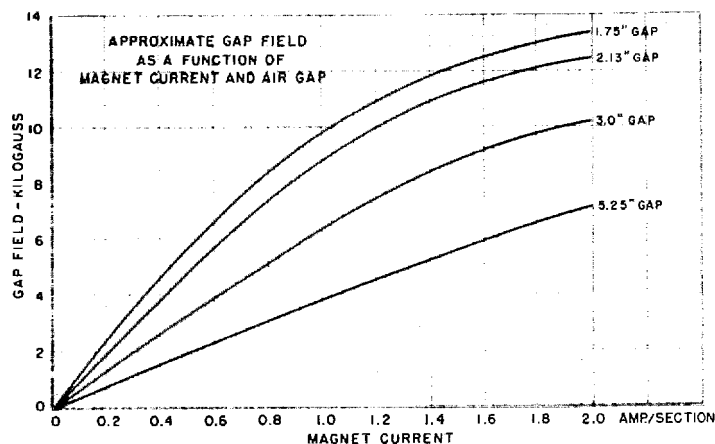
Permendur pole caps tapering from 11.9" diameter to 1" diameter at  $\frac{1}{4}$ " wide air gap. Magnet current = 2 amp./section.

Radial distance from central axis of gap	Approx. gap field with $\frac{1}{8}$ " diam. hole drilled through center of caps and poles for Zeeman Effect work	Approx. gap field when $\frac{1}{8}$ " holes plugged with Permendur
0"	36,000 gauss	38,000 gauss
$\frac{1}{8}$ "	38,300 gauss	38,500 gauss
$\frac{1}{2}$ "	37,500 gauss	37,500 gauss

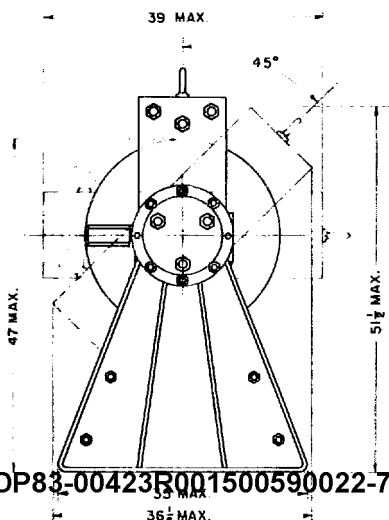
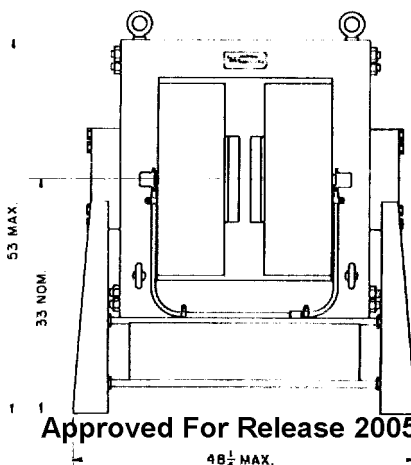
## MAGNETIC DATA



Standard 12-inch cylindrical pole caps



Standard 12-inch cylindrical pole caps



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SIX-INCH LABORATORY  
ELECTROMAGNET

Magnet

V-4007

**DATA SHEET**

The Varian Model V-4007 Six-Inch Electromagnet provides a versatile source of magnetic fields for precise laboratory experiments. Carefully finished cylindrical pole caps may be used for experiments requiring uniform fields; tapered conical pole caps may be used for experiments requiring high fields. *For matching regulated magnet power supply see V-2200 data sheet.*

**FEATURES**

ADJUSTABLE AIR GAP using supplied set of surface-ground yoke spacers

READILY INTERCHANGEABLE POLE CAPS; extra sets machined to provide desired air gap geometry available on order

OPTICAL TECHNIQUES used to check flatness of standard cylindrical pole caps

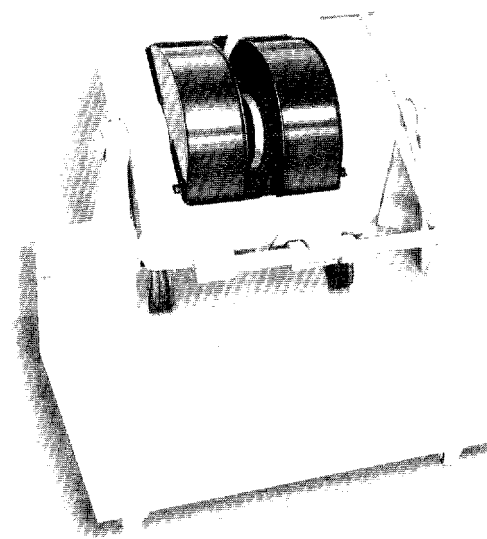
CAREFUL EXPLORATION made with **n-m-r**<sup>1</sup> apparatus to align caps for maximum field uniformity in specified air gap

ELECTROPLATED POLE CAP SURFACES minimize damaging effects of rust and wear

CONTINUOUSLY ADJUSTABLE YOKE ANGLE for best working access

SEPARATELY AVAILABLE COIL SECTIONS permit wide latitude in matching magnet resistance to power supply

COPPER-CLAD ENERGIZING COILS require no cooling water at lower currents; for continuous duty at higher currents, system may be operated with non-recirculating low-pressure tap-water cooling



WATER FILTER supplied for cooling system

TEMPERATURE-SENSING THERMOCOUPLES buried in energizing coils for monitoring and protection of coils if cooling water is left off during continuous operation at higher energizing currents

ELECTRICAL AND WATER CONNECTIONS brought out to standard supplied connectors for direct attachment to power supply, water source, and drain

SURGE PROTECTION prevents damage to coils if sudden accidental magnet current interruption occurs

MOUNTING BASE WITH DOLLY supplied to make equipment mobile in laboratory

**GENERAL CHARACTERISTICS****ELECTRICAL DATA**

Number of energizing coils . . . . .	2
Number of separately available winding sections per energizing coil . . . . .	2
Number of turns per winding section . . . . .	5,500
Total number of turns on magnet . . . . .	22,000
Rated max. magnet current with water cooling . . . . .	1.45 amp./winding section
Equilibrium power at rated max. magnet current with water cooling . . . . .	1.1 kw

**TYPICAL COLD START RESISTANCE DATA**  
(Temp. at thermocouple position = 70°F.)

Resistance per winding section . . . . .	120 ohms
Total resistance of series-connected <sup>2</sup> energizing coils . . . . .	480 ohms
Total resistance of parallel-connected energizing coils . . . . .	30 ohms

**TYPICAL EQUILIBRIUM RESISTANCE DATA**  
(Temp. at thermocouple position = 110°F.)

Resistance per winding section . . . . .	131 ohms
Total resistance of series-connected <sup>2</sup> energizing coils . . . . .	524 ohms
Total resistance of parallel-connected energizing coils . . . . .	32.8 ohms

Max. allowable working voltage between energizing coils and grounded copper sheath encasing coils . . . . . 1350 volts

**COOLING DATA**

Max. required water flow . . . . .	0.5 gallons/min.
Pressure for max. flow <sup>4</sup> . . . . .	15 lbs./in. <sup>2</sup>

**MECHANICAL DATA**

Yoke angle with respect to vertical . . . . .	Continuously variable between 0° and 90°
Approx. weight including rolling base <sup>5</sup> . . . . .	850 lbs.

**NOTES . . .**

- 1 nuclear magnetic resonance
- 2 Magnet is series-connected when used with V-2200 Power Supply.
- 3 Final equilibrium temp. at thermocouple position in coil interior for rated max. current of 1.45 amp./section and water cooling rate of 0.5 gpm. Approx. time required from cold start: 1 hour. Exterior surface temperature of coils rises only a few degrees, due to proximity of outermost layer of cooling coils.
- 4 Water system can withstand pressures up to 100 lbs./in.<sup>2</sup>.
- 5 For shipping weight, add 100 lbs. for crating.

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Pole diameter	6.0 inches
Diameter of standard cylindrical pole caps	6.0 inches
Thickness of each standard cylindrical pole cap	2.0 inches
Min. air gap with standard cylindrical pole caps attached <sup>a</sup>	0.25 inch
Max. air gap with standard cylindrical pole caps attached <sup>a</sup>	6.0 inches
Air gap increments between min. and max. gap using supplied set of yoke spacers <sup>b</sup>	0.25 inch

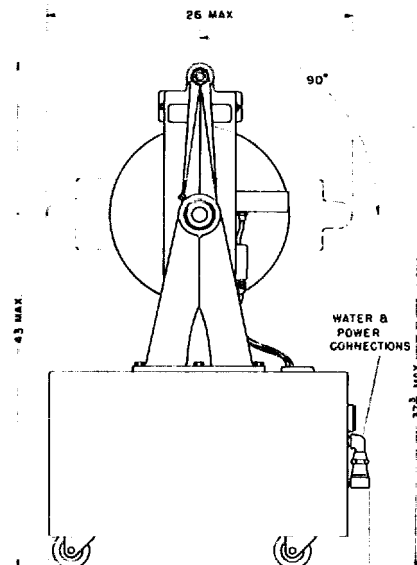
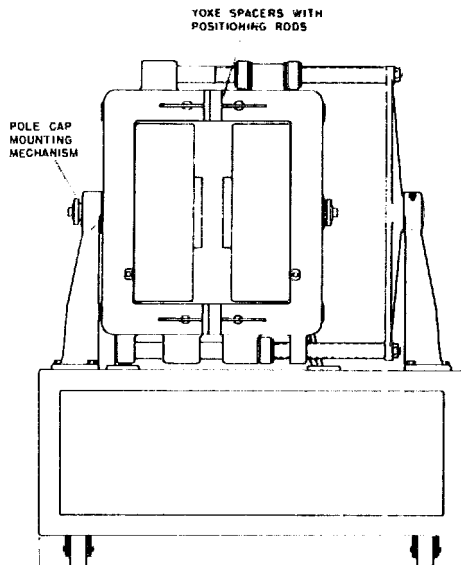
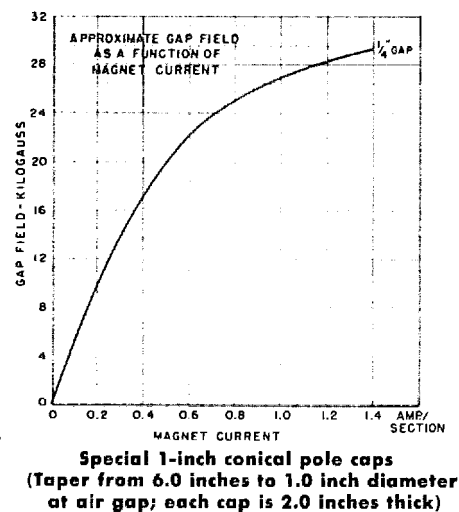
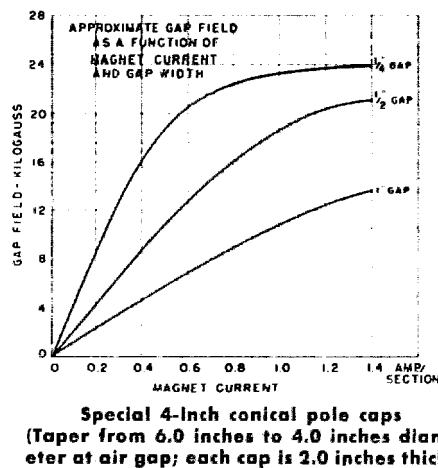
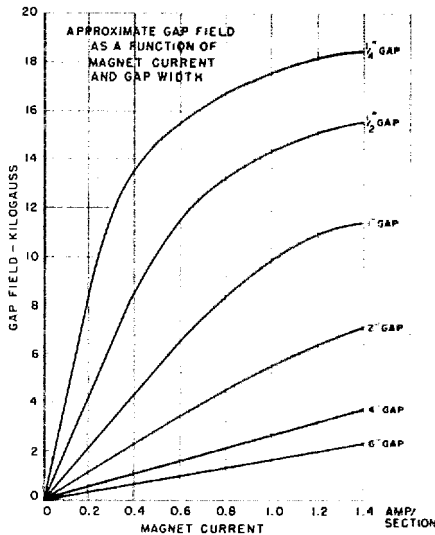
**Typical Approximate Distributions of Magnetic Field in Air Gap with Various Pole Cap and Air Gap Geometries<sup>c</sup>**

	Radial distance from center at which field has fallen off by 1% of central value <sup>a</sup>	Radial distance from center at which field has fallen off by 10% of central value <sup>a</sup>
4" air gap; 6" diam. cylindrical pole caps	1"	2 1/8"
2" air gap; 6" diam. cylindrical pole caps	1 7/8"	2 5/8"
1" air gap; 6" diam. cylindrical pole caps	2 1/2"	2 7/8"
1/2" air gap; 4" diam. conical pole caps	1 5/8"	1 7/8"
1/4" air gap; 1" diam. conical pole caps	3/8"	1/2"

**NOTES . . .**

- Each pole cap is held to corresponding pole by an axial draw-bar secured with a simple locking mechanism. Removal of pole cap in presence of small residual magnetism at zero current is accomplished by a twist of the locking nut and subsequent loosening of the draw-bar.
- Yoke spacers for producing air gaps which are not integral multiples of 0.25" can be supplied on special order.
- Search-coil data taken in median plane of air gap at current of 1.0 amp./section.
- On the gross scale tabulated, constant-field contours are circles with diameters twice the listed radial distances. For example, in a 1" air gap using standard 6" cylindrical pole caps, the circle of uniformity within which the field does not deviate from the central field by more than 1% has a diameter of 5".

**MAGNETIC DATA**





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**REGULATED MAGNET**  
**POWER SUPPLY**

**DATA SHEET**

Power Supply  
**V-2100**  
Voltage Regulator  
**V-2101**

The Varian Model V-2100 Regulated Magnet Power Supply has been specifically designed to provide highly stable direct current for operation of the Varian Model V-4012 Twelve-Inch Laboratory Electromagnet or any other type similar in power and current demand.

The Varian Model V-2101 Voltage Regulator may be added to the V-2100 Power Supply to further extend the degree of regulation of the overall system.

## V-2100 FEATURES

**HIGH-GAIN CHOPPER AMPLIFIER** and parallel audio amplifier in feedback loop insure optimum current regulation against slow and fast changes in line and load; amplifiers have built-in stabilized plate and bias supplies

**RUGGED 304TL PASSING TUBES** permit wide variations in line voltage and load resistance at any given setting of controls

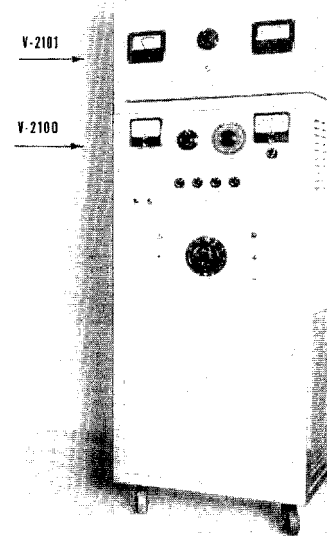
**THERMALLY INSULATED MERCURY CELLS** used in voltage reference circuit minimize drift rate of magnet current; negligible current drain from cells extends life to essentially full shelf life

**MULTI-TURN (5400°) FINE RESOLUTION POTENTIOMETER** and array of low-temperature-coefficient reference resistors mounted in thermally insulated containers to further reduce slow drift to minimum

**SPECIAL SWITCHING CIRCUIT** used to prevent occurrence of spurious resistance effects in reference resistor networks

**FIELD-SWEEPING** and **n-m-r<sup>1</sup>** field stabilizing signals may be injected into system; jacks and controls provided

**COMPLETE METERING** provided for setting current to desired value with simple operating controls



**SAFETY AND INTERLOCK PROTECTION** against accidental magnet current overload, premature application of high voltage to mercury rectifiers, and overheating of supplied magnet

**FILTERED FORCED AIR COOLING** system

**WHEEL-MOUNTING** for mobility in laboratory

**V-2101 VOLTAGE REGULATOR** may be added at any time to further extend stability of system

## GENERAL CHARACTERISTICS OF V-2100

### ELECTRICAL

Max. regulated d.c. output current . . . . .	2.0 amperes
Min. regulated d.c. output current . . . . .	0.02 amperes
Max. regulated d.c. power output . . . . .	5 kw
Max. possible d.c. resistance of magnet load for max. regulated output current . . . . .	1250 ohms
Regulation of output current against input line voltage change <sup>2</sup> or magnet load resistance change of 10% . . . . .	one part in 100,000
Input power requirements of V-2100 at max. output . . . . .	105-125 a.c. volts 2 a.c. amperes single phase 60 cps and 208-220 volts 20 a.c. amperes 3-phase 60 cps

### MECHANICAL

Height . . . . .	62 in.
Depth . . . . .	27 in.
Width . . . . .	27 in.
Weight <sup>3</sup> . . . . .	600 lbs.

### NOTES . . .

1 nuclear magnetic resonance

2 Due to large time-constant of supplied magnet, rapid line voltage fluctuations about a roughly constant average value of line voltage will result in magnet current changes much smaller than those specified here. Line voltage changes lasting for a few seconds or longer will be reflected in magnet current shifts as specified.

3 For shipping weight on V-2100, add 50 lbs. for crating.

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# THE V-2101 VOLTAGE REGULATOR.....

EXTENDS REGULATION OF V-2100 Power Supply against line voltage fluctuations by an order of magnitude and reduces minute residual gap field ripple correspondingly to small fraction of a milligauss. Result accomplished electronically through use of 304TL passing tubes, amplifier, reference voltage, error signal resistors, and special circuitry for complete suppression of troublesome oscillations normally encountered in extremely high gain feedback loops

ADDS DIRECTLY TO V-2100 Power Supply by single supplied cable and connector. (Output jacks of all V-2100 Power Supplies are pre-wired to accept either the magnet load alone or the magnet load and V-2101 Voltage Regulator when needed). When cable between units is connected, the V-2100 and V-2101 are completely interlocked, and the on-off switching is controlled as before from V-2100. Filament, fan, and relay power obtained from single-phase line

## GENERAL CHARACTERISTICS OF V-2101

### ELECTRICAL

Max. permissible regulated d.c. output current of V-2100 Power Supply when V-2101 Voltage Regulator added to system . . . . . 1.05 amperes  
 Min. regulated d.c. output current of V-2100 Power Supply when V-2101 Voltage Regulator added to system . . . . . 0.02 amperes  
 Regulation of combined system (V2100 + V-2101) against line voltage change<sup>2</sup> of 10% . . . . . one part in one million  
 Input power requirement of V-2101 . . . . . 105-125 a.c. volts  
 . . . . . 6 a.c. amperes  
 . . . . . single-phase 60 cps

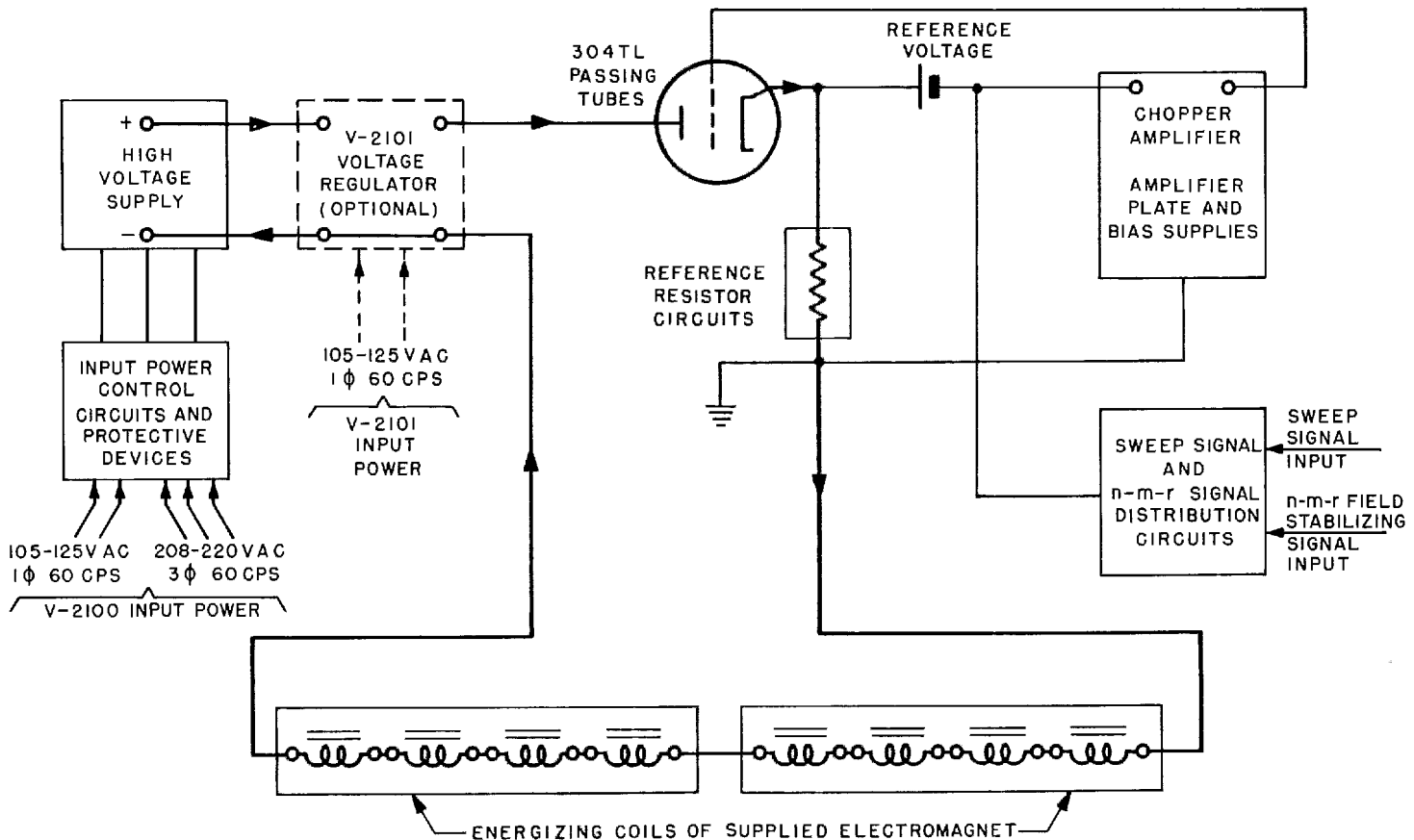
### MECHANICAL

Height . . . . . 16 1/4 in.  
 Depth . . . . . 27 in.  
 Width . . . . . 27 in.  
 Weight<sup>4</sup> . . . . . 250 lbs.

### NOTES . . .

4 For shipping weight on V-2101, add 25 lbs. for crating.

Block diagram of Varian V-2100 Regulated Magnet Power Supply and V-2101 Voltage Regulator





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Power Supply

**REGULATED MAGNET**  
**POWER SUPPLY**

**V-2200**

**DATA SHEET**

The Varian Model V-2200 Regulated Magnet Power Supply has been specifically designed to provide highly stable direct current for operation of the Varian Model V-4007 Six-Inch Laboratory Electromagnet or any other type similar in power and current demand.

## FEATURES

HIGH-GAIN CHOPPER AMPLIFIER and parallel audio amplifier in feedback loop insure optimum current regulation against slow and fast changes in line and load; amplifiers have built-in stabilized plate and bias supplies

RUGGED 304TL PASSING TUBES permit wide variations in line voltage and load resistance at any given setting of controls

THERMALLY INSULATED MERCURY CELLS used in voltage reference circuit minimize drift rate of magnet current; negligible current drain from cells extends life to essentially full shelf life

MULTI-TURN (5400°) FINE RESOLUTION POTENTIOMETER and array of low-temperature-coefficient reference resistors mounted in thermally insulated containers to further reduce slow drift to minimum

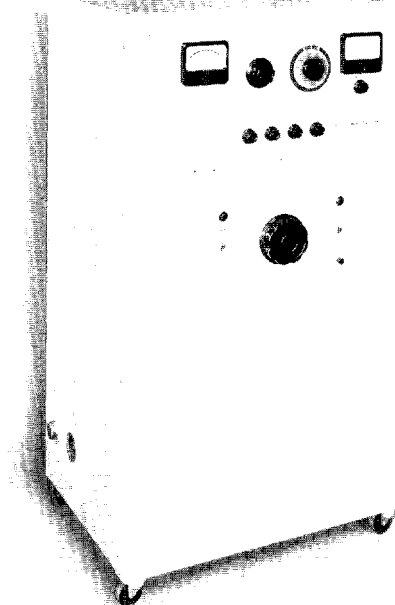
SPECIAL SWITCHING CIRCUIT used to prevent occurrence of spurious resistance effects in reference resistor network

FIELD-SWEEPING and  $n-m-r^1$  field stabilizing signals may be injected into system; jacks and controls provided

COMPLETE METERING provided for setting current to desired value with simple operating controls

SAFETY AND INTERLOCK PROTECTION against accidental magnet current overload, premature application of high voltage to mercury rectifiers, and over-heating of supplied magnet

FILTERED FORCED AIR COOLING system



WHEEL-MOUNTING for mobility in laboratory

SINGLE-PHASE input power requirement

EXTERNAL A.C. LINE VOLTAGE REGULATOR may be used to further extend stability of system

UNREGULATED D.C. VOLTAGE AVAILABLE at output terminals for magnet or general laboratory use; a single jumper connection change bypasses current regulator

## GENERAL CHARACTERISTICS

### ELECTRICAL

Max. <i>regulated</i> d.c. output current . . . . .	1.4 amperes
Min. <i>regulated</i> d.c. output current . . . . .	0.03 amperes
Max. <i>regulated</i> d.c. power output . . . . .	1.15 kw
Max. possible d.c. resistance of magnet load for max. regulated output current . . . . .	585 ohms
Regulation of output current against input line voltage change <sup>2</sup> or magnet load resistance change of 10% . . . . .	one part in 100,000
Max. <i>unregulated</i> output voltage . . . . .	1500 volts
Max. <i>unregulated</i> output current . . . . .	1.5 amperes
Input power requirement at max. output . . . . .	105-125 a.c. volts 32 a.c. amperes single-phase 60 cps

### MECHANICAL

Height . . . . .	57½ in.
Depth . . . . .	24½ in.
Width . . . . .	32 in.
Weight <sup>3</sup> . . . . .	525 lbs.

### NOTES . . .

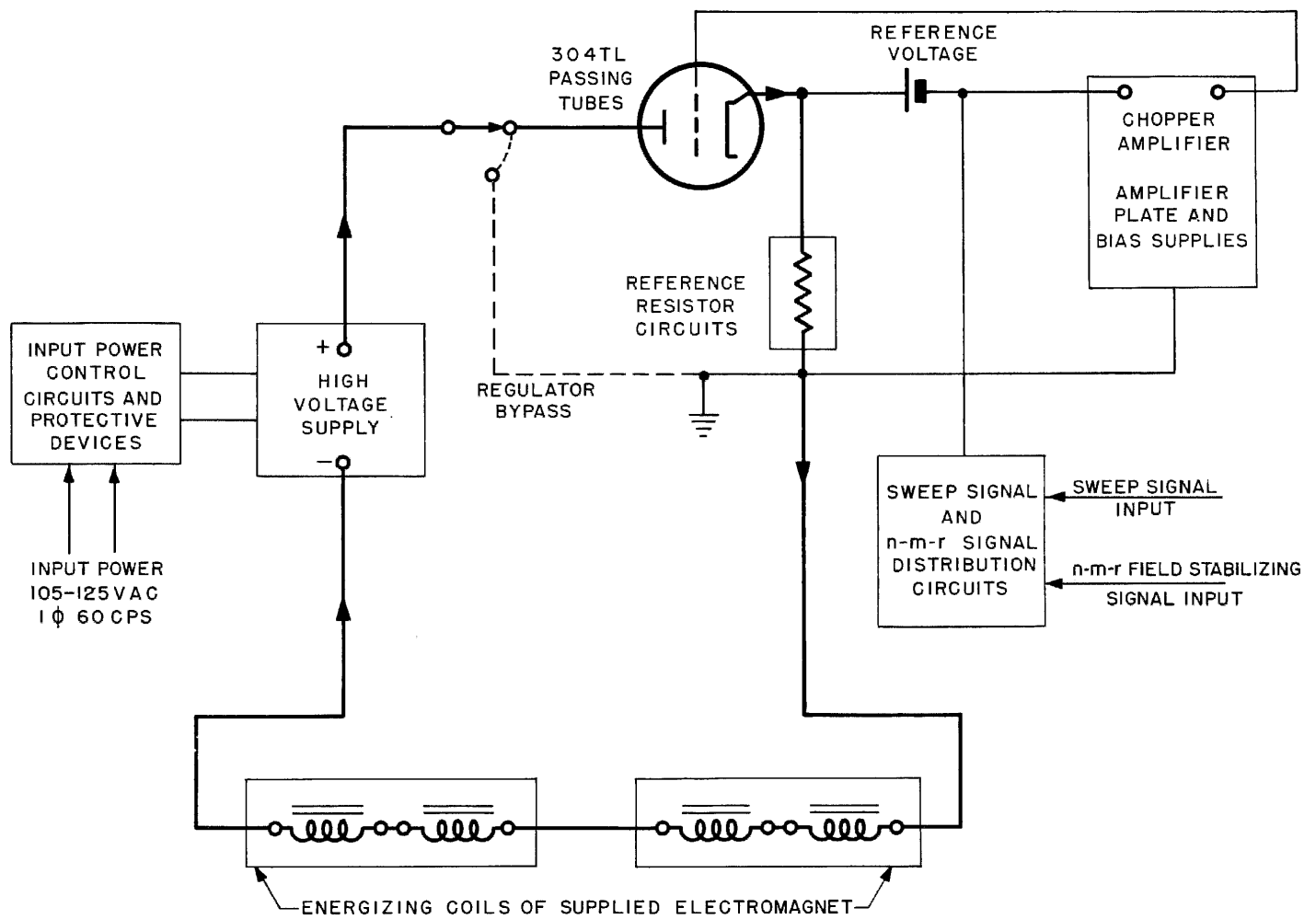
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Block Diagram of Varian V-2200 Regulated Magnet Power Supply



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25X1

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